SPECIFICATION

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[LIGHT EMITTING DIODE HAVING AN INSULATING SUBSTRATE]

Background of Invention

[0001] 1.Field of the Invention

[0002] The present invention relates to a light emitting diode (LED), and more particularly, to a light emitting diode having an insulating substrate.

[0003] 2.Description of the Prior Art

[0004] Light emitting diodes (LEDs) are employed in a wide variety of applications including optical display devices, traffic lights, data storage equipment, communication devices, illumination apparatuses, and medical treatment equipment. One of the main goals of engineers who design LEDs is to increase the brightness of the light emitted from LEDs.

[0005] U.S. patent No.5,563,422 discloses a gallium nitride (GaN)-based LED in Fig.10. The LED has a p-type ohmic contact electrode 56 made of nickel, gold or a nickel-gold alloy. The LED also has an n-type ohmic contact electrode 57 made of titanium, aluminum, or a titanium-aluminum alloy. Since the electrodes 56 and 57 are made of different materials, two evaporation processes and two photolithographic processes are required to form the electrodes 56 and 57, respectively.

Summary of Invention

[0006] It is an objective of the claimed invention to provide an LED having a p-type ohmic contact electrode and an n-type ohmic contact electrode made of the same materials.

[0007] According to the claimed invention, the LED includes an insulating substrate; a buffer layer positioned on the insulating substrate; an n^+-type contact layer positioned on the buffer layer, the contact layer having a first surface and a second surface; an n-type cladding layer positioned on the first surface of the n^+-type contact layer; a light-emitting layer positioned on the n-type cladding layer; a p-type cladding layer positioned on the light-emitting layer; a p-type contact layer positioned on the p-type cladding layer; an n^+-type reverse-tunneling layer positioned on the p-type contact layer; a p-type transparent ohmic contact electrode positioned on the n^+-type reverse-tunneling layer; and an n-type transparent ohmic contact electrode positioned on the second surface of the n^+-type contact layer. The p-type transparent ohmic contact electrode and the n-type transparent ohmic contact electrode are made of the same materials.

[0008] It is an advantage of the claimed invention that the p-type ohmic contact electrode and the n-type ohmic contact electrode are made of the same materials, thus only an evaporation process and a photolithographic process are required for simultaneously forming the p-type ohmic contact electrode and the n-type ohmic contact electrode to reduce the production costs of the LED.

[0009] These and other objectives of the claimed invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

Brief Description of Drawings

[0010] Fig.1 is a schematic diagram of an LED having an insulating substrate according to a better embodiment of the present invention.

Detailed Description

[0011]

Please refer to Fig.1 of a schematic diagram of an LED having an insulating substrate according to a better embodiment of the present invention. The LED includes a stacked structure, which is composed of a sapphire insulating substrate 10, a GaN buffer layer 11 positioned on the insulating substrate 10, an n^+-type GaN contact layer 12 positioned on the buffer layer 11, an n-type AlGaN cladding layer 13 positioned on the n^+-type contact layer 12, an InGaN light-emitting layer 14 with a

multiple-quantum well (MQW) structure positioned on the n-type cladding layer 13, a p-type AlGaN cladding layer 15 positioned on the light-emitting layer 14, a p-type GaN contact layer 16 positioned on the p-type cladding layer 15, and an n^{+}-type InGaN reverse-tunneling layer 20 positioned on the p-type contact layer 16.

[0012] Since sapphire is dielectric, a portion of the stacked structure of the LED has to be etched, exposing a portion of the n^{+}-type contact layer 12. Following this, an ITO layer is formed on the exposed surface of the LED. A photolithographic process is then used to form a p-type transparent ohmic contact electrode 17 on the n^{+}-type reverse-tunneling layer 20, and form an n-type transparent ohmic contact electrode 19 on the exposed portion of the n^{+}-type contact layer 12, respectively.

[0013] In a better embodiment of the present invention, the n^{+}-type reverse-tunneling layer 20 has a high carrier concentration of approximately 1.5×10^{20} cm^{-3}, a thickness of approximately 20 angstroms, and provides high transparency. The p-n junction between the reverse-tunneling layer 20 and the contact layer 16, and the p-n junction between the cladding layers 15 and 13 must be in opposite bias conditions to induce electron tunneling through the reverse-tunneling layer 20 according to a tunneling effect. For example, when p-n junction between the reverse-tunneling layer 20 and the contact layer 16 is in a forward bias condition, the p-n junction between the cladding layers 15 and 13 must be in a reverse bias condition. Alternatively, when the p-n junction between the reverse-tunneling layer 20 and the contact layer 16 is in a reverse bias condition, the p-n junction between the cladding layers 15 and 13 must be in a forward bias condition.

[0014] In addition, in other embodiments of the present invention, the multiple-quantum well structure for the InGaN light-emitting layer 14 can be replaced with a single-quantum well structure. The GaN buffer layer 11 and/or the p-type contact layer 16 can be optional to be removed from the LED structure. The n^{+}-type GaN materials can be replaced with n-type GaN materials.

[0015] In contrast to the prior art, the p-type transparent ohmic contact electrode 17 and the n-type transparent ohmic contact electrode 19 of the LED of the present invention are made of the same materials, such as ITO, CTO or TiWN. Therefore, the manufacturing procedures of LEDs are simplified, and the production costs are

effectively reduced according to the present invention.

[0016] Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.